Spanish Consumers' Attitudes and Acceptability towards GM Food Products

Ana M. Angulo and José M. Gil*

Abstract

The objective of this paper is to analyse consumers' attitudes and acceptability of GM food products in Spain. From the methodological point of view, a three-equation model of consumer behaviour is estimated assuming a kind of causal chain among the degree of knowledge, attitudes and buying intentions. Explanatory variables include socio-economic characteristics of respondents as well as endogenous variables of the previous equations. The model provides a better knowledge of how attitudes and buying intentions towards GM food are formed. Higher educated consumers, more concerned about labelling information and less about price, and regular buyers of organic foods show a higher (not necessarily better) knowledge on GM technology and its consequences. However, those consumers with a lower level of knowledge, together with those who are not concerned about safety, are not used to recycle but to purchase fast food generate more positive attitudes towards GMs, which finally determine future purchasing intention.

Key words: *GM foods, Spain, consumers' attitudes, econometric model*

Introduction

Biotechnology has become an expanding discipline with a wide variety of applications including agriculture and food production. Agro-food applications of genetic manipulation technology has proved to be able to provide a cost efficient way to produce new, value added or price competitive food products. Initially, Genetically Modified (GM) products were targeted to producers and the rate of adoption has been relatively important, mainly in the United States.

The global area of transgenic crops was 1.7 million has., in 1996, having increased more than 52-fold in only 9 years to reach 90 million has., in 2005, grown by 8.5 million farmers in 21 countries (James, 2005). Only seven countries grew almost 97% of the total transgenic crop area: USA (55%), Argentina (19%), Brasil (10%), Canada (6%), China (4%), Paraguay (2%) and India (1%). Among them, China shows the highest growth in the last years. Other 7 countries grew transgenic crops, at least, marginally: Australia, Mexico, Bulgaria, Uruguay, Romania, Spain, Indonesia and Germany. The principal GM crops are soybean (60% of total area), corn (24%), cotton (11%) and canola (5%). The dominant traits are herbicide tolerance and insect resistance.

* Ana M. Angulo: Departamento de Análisis Económico, Universidad de Zaragoza (Spain)
José M. Gil (corresponding autor): CREDA-UPC-IRTA, Edifici ESAB – Parc Mediterrani de la Tecnologia, Avinguda del canal Olimpic, s/n **08860-** Castelldefels (Barcelona – Spain),
Phone: +34-93-5521210, Fax: +34-93-5521121, Email: chema.gil@upc.edu

In spite of such apparent success among farmers, nowadays, genetic manipulation techniques have become a topical and controversial issue with intensive media coverage. Society has recognised that together with some benefits to farmers there may exist some risks to humans although, at least up to our knowledge, the extent of those risks is as yet unknown. Consumers' concerns have generated some reactions of public authorities, placing restrictions on imports or imposing mandatory labelling for foodstuffs containing GM ingredients. Although such consumers' concerns took place initially in European countries, they have been extended worldwide.

Several studies have recognized the importance of a better understanding of consumers' reactions to GM food. Early studies focussed on their attitudes and perceptions towards the new products. Most of them were very qualitative in nature simply offering ratings of general attitudes or whether consumers were willing to purchase these products (Kelley, 1995; Hoban, 1998; Smith and Riethmuller, 1999; Wolf and Domegan, 2002; Spetsidis and Schamel, 2001; and Mendenhall and Evenson, 2002; among others). More recently, studies on consumers' acceptability of GM products have become more quantitative trying to incorporate the circumstances under which GM products become available. Contingent valuation (Boccaletti and Moro, 2000; and Moon and Balasubramanian, 2001) and choice modelling (Burton et al., 2001; and Chern and Rickertsen, 2002) have been the most useful tools to analyse to what extent consumers were willing to pay non-GM products. More recently, Verdurme and Vianne (2002) have specified a Structural Equation Model to analyse a hypothetical model including consumers': 1) socio-demographic characteristics; 2) attitudes towards food; 3) knowledge about GM technology; 4) beliefs; and 5) attitudes towards GM food, for different consumer segments. However, the validity of the hypothetical model is only assessed for individual relationships: 1) and 2) on 3); 3) on 4); and 4) on 5).

This paper lies in the last set of studies being the main objective to jointly analyse consumers' knowledge, attitudes and acceptability of GM food products in Spain. From the methodological point of view, an attempt is made to estimate a complete model of consumer behaviour.

Consumer beliefs, attitudes and behaviour may occur directly or indirectly (Mowen, 1993; and Verdurme et al., 2001). In the first case, the three elements are created independent of each other. In the second case, a kind of causal chain among the three elements can be established, taking into account that in the case of GM products we are referring to behavioural intention due to the limited availability of such products.

In this paper a three-equation model is estimated. The three equations are: the level of information consumers have, their attitudes towards GM food, and, finally, their willingness to buy such products. Explanatory variables include socio-economic characteristics and lifestyles of respondents as well as endogenous variables from previous equations. The aim is to provide a better knowledge of how attitudes and buying intentions towards GM food are formed.

The paper is organised as follows. First, some descriptive data from the survey is offered. Second, the theoretical model of consumer behaviour is formulated as well as its econometric specification. Third, results from the estimated model are provided. Finally, some concluding remarks are outlined.

Consumers' knowledge, attitudes and purchasing intention towards GM food

Data used in this study come from a telephone survey carried out at national level using a random digit dialling method. In total 660 responses were collected as valid. Respondents were selected according to a proportional quota sampling method with age of the household head and region as quota variables. A similar structured questionnaire as

Table 1. Main Socio-economic Characteristics and Purchasing Habits of Respondents

Household size (number)	3.32
Age (years)	47.28
Education level (%):	
Primary	46.4
Secondary	38.5
University	15.1
Geographical distribution (%)	
North-East	13.5
North-West	11.2
Centre	13.9
East	27.0
South	20.8
Madrid	13.6
Weekly expenditure on food (€/capita)	35.16
Weekly expenditure on organic food (€/capita)	1.30
Weekly away-from-home expenditure (€/capita)	3.46
Vegetarian (%)	6.2
Female (%)	70.2
Buy organic food?	
Never or rarely	72.1
Sometimes	21.5
Often or always	6.4
Buy fast foods?	
Never or rarely	78.2
Sometimes	18.0
Often or always	3.8
Buy tobacco products?	
Never or rarely	18.5
Sometimes	7.5
Often or always	74.0
Recycle paper, cans or bottles?	
Never or rarely	65.6
Sometimes	3.5
Often or always	30.9

in Chern and Rickertsen (2002) was used. It was divided into five sections. First consumers' knowledge and awareness towards GM products was investigated. Second, consumers' attitudes and perceptions to food attributes and more specifically towards GM products were explored. The third section dealt with labelling. The fourth section was devoted to buying intentions where respondents had to choose between the GM and the counterpart non-GM product. Corn flakes are used as an example. Finally, the questionnaire collected some socio-economic characteristics and purchasing habits of respondents whose average values are summarized in Table 1.

Let us briefly describe some of the main results dealing with Spanish consumers' knowledge and awareness, attitudes and purchasing intentions of GM food. We will compare the results obtained from this survey with those found in Chern and Rickertsen (2002) for US and Norway. Table 2 shows that 61% considered they were not informed about GM foods, a percentage which is much higher than in the case of Norway and US even though the survey was implemented nine months later and during that period the number of existing debates and information available on press and TV has notably increased. Only 3.5% of Spanish respondents considered themselves very well informed.

The questionnaire also included two knowledge statements trying to detect if consumers' knowledge was correct. Results are also included in Table 2. Consistent with the previous question, almost two thirds of respondents did not know if the statement "Non-genetically modified soybeans do not contain genes while genetically modified soybeans do" was true or false. Only 23.5% of respondents answered correctly to this statement, a percentage much lower than in the other two countries considered. In relation to the second statement "By eating GM foods, a person's genes could be altered", almost 32% of respondents believed it was false, a more or less similar result than that obtained for Norway but far away from US respondents who, in general terms, showed a better knowledge about GM foods. In the case of Spain, the degree of knowledge was better among younger and higher educated people.

Table 2. Consumers' Knowledge about GM Food in Spain (%)

	Alternative	*Norway*	*US*	*Spain*
Before this survey, how well were you informed about GM food?	Very well	8.0	14.0	3.5
	Somewhat	45.0	41.0	35.5
	Not informed	47.0	44.9	61.0
Non-genetically modified soybeans do not contain genes while genetically modified soybeans do	True	16.0	23.4	11.5
	False	37.5	43.8	23.5
	Don't know	46.5	32.8	65.0
By eating GM foods, a person's genes could be altered	True	28.0	22.3	22.7
	False	36.0	61.3	31.8
	Don't know	36.0	16.4	45.5

Source: Chern and Rickertsen (2002, Table 4) and own elaboration.

In Table 3 some Spanish respondents' attitudes towards GM foods are presented. Around 44% of respondents believed that GM foods were risky for human health while only 8% judged them as safe. Moreover, the number of respondents who did not have a

Table 3. Consumers' Attitudes towards GM Foods in Spain

	Country	*Extremely (1)*	*Somewhat (2)*	*Neither (3)*	*Somewhat (4)*	*Extremely (5)*	*Don't know*
How would you rate GM foods in terms of risk for human health? (1=risky,…,5=safe	Norway	33.5	26.0	8.0	13.0	10.5	9.0
	USA	9.4	39.5	16.0	15.2	5.5	14.5
	Spain	9.3	34.4	29.8	7.3	0.6	18.6
How willing are you to consume foods produced with GM ingredients? 1=willing,…,5=unwilling	Norway	13.0	17.5	4.0	18.0	45.5	2.0
	USA	4.7	38.3	13.7	23.8	16.4	3.1
	Spain	2.3	18.9	13.9	14.5	45.6	4.8
How willing would you be to consume GM food if it reduced the amount of pesticide applied to crops? 1=willing,…,5=unwilling	Norway	17.0	21.5	9.5	11.5	35.5	5.0
	USA	13.7	54.7	9.4	11.3	9.0	2.0
	Spain	7.7	31.4	11.2	22.9	23.0	3.8
How willing would you be to consume GM food it was more nutritious? 1=willing,…,5=unwilling	Norway	17.5	19.5	7.5	10.0	39.0	6.5
	USA	18.0	53.9	5.1	9.4	10.9	2.7
	Spain	10.2	30.8	10.2	15.3	29.5	4.1
How willing would you be to consume GM food if it posed a risk causing allergic reactions? 1=willing,…,5=unwilling	Norway	1.5	8.5	2.0	4.0	83.5	0.5
	USA	3.5	21.5	5.9	26.2	41.4	1.6
	Spain	0.6	1.5	1.4	5.8	88.6	2.1
How important are ethical or religious concerns when deciding whether to consume or not GM foods? 1=important,…,5=unimportant	Norway	21.5	8.0	3.5	2.5	62.5	2.0
	USA	12.5	23.8	15.2	18.0	28.9	1.6
	Spain	3.3	3.6	11.4	13.5	62.0	6.2

Source: Chern and Rickertsen (2002, Table 4) and own elaboration.

clear opinion or simply did not know what to answer was relatively high (18% of respondents). In the case of Norway, respondents were more precise (60% perceived GM foods as risky for human health while 35% thought they were safe). In the US results were similar than in the case of Spain, although the number of undecided population was lower.

The lower degree of knowledge and the negative image of GM foods determine that, in the case of Spain, only 20% of respondents were willing to consume foods produced with GM ingredients (percentages were 30 %, for Norway, and 43%, for US) and, quite surprisingly here, the number of undecided respondents were very low. On the opposite side, 45% of Spanish respondents were extremely unwilling to consume GM foods, a similar percentage as in Norway. In the US, opinions were not so extreme and the larger percentage of respondents concentrated their answers in the "somewhat" box (either willing or unwilling).

Respondents' attitudes towards GM food were toned down when some benefits associated to the GM food were explicitly included in the question. Two main benefits were included: 1) the reduction of pesticides in agricultural production; and 2) the improvement of the nutritional content of the "new" food. In Spain, around 20% of respondents changed their opinion in favour of GM foods when associated benefits were mentioned to them (the percentage is slightly higher when the nutritional content is improved). In US similar patterns have been observed, that is, consumers' willingness to consume GM foods increased in higher proportion when the benefit refers to the improvement of the nutritional value (the percentage of respondents who changed their mind towards GM foods was 30% when the nutritional value is improved while the percentage is only 25% if the benefit is related to pesticides reduction). Finally, in Norway, benefits associated to the production of GM food only generated a slight change in consumers' attitudes. In fact, the percentage of respondents willing to consume GM foods only changes by 8%, independently of the associated benefit.

Finally, potential sources of concern among consumers were also investigated. When respondents were faced with the potential risk of causing allergic reactions to people, 89% of Spanish, 84% of Norwegians and 40% of Americans were extremely unwilling to consume GM food. On the opposite side, 35% of Americans seems to accept the risk while this percentage is much lower in Norway (10%) and Spain (2%).

Ethical and religious considerations are not important for European consumers when deciding to consume or not GM foods. In fact, 75% of Spanish and 65% of Norwegian respondents declare such concerns as somewhat or extremely unimportant. In US, on the contrary, ethical and religious concerns are important for one third of respondents.

As a conclusion, from Table 3 it seems that European consumers are less favourable to GM foods than people in the US. In relation to the two European countries, Spanish respondents show a lower degree of knowledge and a larger number of undecided people about genetic modification technology.

Let us finish this presentation of the main descriptive results obtained from the questionnaire saying something about the purchasing intention of respondents. We asked respondents to choose between a non-GM and a GM corn flake box assuming identical prices for both of them. The selected price or base price was a simple average of market prices of two brands in twenty-five retail outlets all over Spain. Results indicated that 70% of respondents would choose the non-GM product, 5% indicated that both products

were attractive, 18% would choose neither the GM nor the non-GM product, and finally, only 7% would select the GM corn flakes box.

In a next step, we have assumed that GM food products are cheaper than the non-GM counterpart. The same options as above were offered to respondents including some price reductions (from 10% to 30%) for the GM corn flakes box. Only 4% of respondents changed their mind from non-GM to GM corn flakes but the more surprising result is that such percentage was almost identical independently of the price reduction offered to respondents, indicating that prices cannot be considered as a determinant of consumer behaviour, at least in relation to GM food products.

To what extent consumers' knowledge and awareness about GM foods affect their attitudes and how attitudes are related to purchasing intention, the main objective of this paper, will be discussed in the next section.

Theoretical and econometric model

It is widely acknowledged that consumers' decisions are the result of a complex process not always very well understood as many personal and environmental factors may contribute to final choices. Consumers' knowledge or beliefs, attitudes and behaviour are formed interdependently following some kind of causal chains or hierarchies of effects. There exist three main hierarchies of effect models depending on the purchasing situations (Verdurme et al., 2001):

a) The standard or high-involvement hierarchy assumes that the consumer is a rational problem solver. In this case, the order of consumer responses is the following: knowledge is first, then attitudes and finally behaviour (learn-feel-do).
b) In low-involvement purchasing situations, where consequences of a wrong decision are very limited, beliefs come first, then behaviour and finally attitudes (learn-do-feel).
c) In impulse purchases or situations where consumers are highly involved with the final outcome, the experiential hierarchy applies. In this case behaviour comes first, then attitudes and finally knowledge (do-feel-learn).

Recent food scares has increased consumers' concerns on food products which has provoked that many food products have moved from the low involvement categories to the high ones. It means that consumers want to be better informed before taking decisions making attitudes highly dependent on the degree of knowledge. Finally, both beliefs and attitudes affect purchasing decisions. It is assumed that respondents' socio-economic characteristics and food habits and lifestyles may affect the three dimensions of our model.

Taking these issues into account, three dependent variables have been defined: knowledge of GM technology (K_i), consumer attitudes towards GM products (A_i) and, finally, GM foods purchasing intention (C_i). These three variables are modelled as a recursive system such that A_i is explained by K_i, and C_i is explained by A_i as it is shown in Figure 1. In what follows, vectors of explanatory variables x_i^K, x_i^A and x_i^C are used to explain knowledge, attitudes and purchasing intention, respectively, with corresponding parameter vectors β^K, β^A, β^C and random errors ε_i^K, υ_i^A and υ_i^C.

Knowledge is a binary variable indicating whether an individual has some information about GM products before the survey ($K_i = 1$, if respondents were very well or somewhat informed, see Table 2) or not ($K_i = 0$) and is characterized by a binary response model:

$$K_i = \begin{cases} 1 & \text{if} \quad K_i^* = \beta^K x_i^k + \varepsilon_i^k > 0 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where: the random error ε_i^k is distributed as $N(0,1)$, and K_i^* is the corresponding latent variable measuring knowledge level.

The consumer attitude towards GMO products (A_i) is a categorical variable, measuring how willing consumers are to consume foods produced with GM ingredients. The original five ordered degrees (Table 3, 2nd row) have been reduced to three (low, medium and high) (the extreme and somewhat categories have been jointly considered). Consequently, this variable has been categorised by an ordered polychotomous response model:

$$A_i^* = \beta^A x_i^A + \alpha^A K_i^* + \upsilon_i^A > 0 \tag{2}$$

$$A_i = j \quad if \quad \mu_{j-1} < A_i^* \le \mu_j, \quad j = 1,2,3$$

where α^A is a scalar parameter, υ_i^A is distributed as $N(0,1)$, and threshold parameters μ_j are normalized such that $\mu_0 = -\infty$, $\mu_1 = 0$ and $\mu_3 = \infty$ for identification. Finally, A_i^* is the corresponding latent variable measuring the level of this type of attitude.

GM foods purchasing buying intention (C_i) is modelled using a binomial variable:

$$C_i = \begin{cases} 1 & \text{if} \quad C_i^* = \beta^C x_i^C + \alpha^C A_i^* + \upsilon_i^C > 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

where α^C is a scalar parameter and υ_i^C is distributed as $N(0,1)$.

To sum up, the random-error vector $\{\varepsilon_i^K, \upsilon_i^A, \upsilon_i^C\}$ is normally distributed with zero mean vector and covariance matrix:

$$\begin{bmatrix} 1 & \sigma_{KA} & 0 \\ & 1 & \sigma_{AC} \\ & & 1 \end{bmatrix} \tag{4}$$

Note that since K_i^* and A_i^* in (2) and (3), respectively, are unobserved, and K_i and A_i, respectively, are not a good proxy for it, we use $\hat{K}_i^* = \hat{\beta}^K x_i^k$ and $\hat{A}_i^* = \hat{\beta}^A x_i^A + \hat{\alpha}^A \hat{K}_i^*$, instead to explain knowledge and attitudes towards GM food products. Therefore, the model for explaining attitudes towards GM foods becomes:

$$A_i^* = \beta^A x_i^A + \alpha^A \hat{K}_i^* + \varepsilon_i^A > 0 \tag{5}$$
$$A_i = j \quad if \quad \mu_{j-1} < A_i^* \le \mu_j, \quad j = 1,2,3$$

and the model for explaining GM purchasing intention is as follows:

$$C_i = \begin{cases} 1 & \text{if} \quad C_i^* = \beta^C x_i^C + \alpha^C \hat{A}_i^* + \varepsilon_i^C > 0 \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

The composite errors are given by

$$\varepsilon_i^A = \upsilon_i^A + \alpha^A \varepsilon_i^K \quad \text{and} \quad \varepsilon_i^C = \upsilon_i^C + \alpha^C \varepsilon_i^A$$

where the terms $\alpha^A \varepsilon_i^K$ and $\alpha^C \varepsilon_i^A$, result from using $\hat{K}_i^*$ and $\hat{A}_i^*$ instead of K_i^* and A_i^*, respectively.

Accordingly, the composite error vector $\{\varepsilon_i^K, \varepsilon_i^A, \varepsilon_i^C\}$ is distributed as multivariate normal with zero mean vector and covariance matrix:

$$\Omega = \begin{bmatrix} 1 & \sigma_{KA} + \alpha^A & \alpha^C(\sigma_{KA} + \alpha^A) \\ & 1 + (\alpha^A)^2 + 2\alpha^A \sigma_{KA} & \sigma_{AC} + \alpha^C(1 + \alpha^A \sigma_{KA}) + \alpha^A \alpha^C(\sigma_{KA} + \alpha^A) \\ & & 1 + (\alpha^C)^2 + 2\alpha^C \sigma_{CA} \end{bmatrix} \tag{7}$$

The three equations are jointly estimated by maximum likelihood. To contruct the sample likelihood function the probabilities for each scenario have to be defined. They are given by:

$$\begin{aligned} &\Pr(K_i = l, A_i = j, C_i = l') = \\ &= \Psi\left[(2l-1)\beta^K x_i^K; \mu_j - \beta^A x_i^A - \alpha^A \hat{K}_i^*; (2l'-1)\left(\beta^C x_i^C + \alpha^C \hat{A}_i^*\right); W_i' \Omega W_i\right] \\ &- \Psi\left[(2l-1)\beta^K x_i^K; \mu_{j-1} - \beta^A x_i^A - \alpha^A \hat{K}_i^*; (2l'-1)\left(\beta^C x_i^C + \alpha^C \hat{A}_i^*\right); W_i' \Omega W_i\right] \end{aligned} \tag{8}$$

where $\Psi[\cdot,\cdot,\cdot;\cdot]$ is the trivariate normal cumulative density function (CDF) with the last element being the covariance matrix. Furthermore, $W_i = \text{diag}\{(2l\text{-}1), 1, (2l'-1)\}$, with $(2l'-1)$ and W_i accommodating sign changes in the integration limit and covariance matrix while evaluating the trivariate normal probabilities as lower-tailed CDFs.

Finally, using expression (8) and a dichotomous index d_{ij} defined such that $d_{ij} = 1$ if $A_i = j$ and zero otherwise, the sample likelihood function adopts the following expression:

$$
\begin{aligned}
L = & \prod_{K_i=1, C_i=1} \prod_{j=1}^{3} \left[\Pr\left(K_i = 1,\ A_i = j, C_i = 1\right)\right]^{d_{ij}} \\
& \text{x} \prod_{K_i=0 C_i=1} \prod_{j=1}^{3} \left[\Pr\left(K_i = 0,\ A_i = j, C_i = 1\right)\right]^{d_{ij}} \\
& \text{x} \prod_{K_i=1 C_i=0} \prod_{j=1}^{3} \left[\Pr\left(K_i = 1,\ A_i = j, C_i = 0\right)\right]^{d_{ij}} \\
& \text{x} \prod_{K_i=0 C_i=0} \prod_{j=1}^{3} \left[\Pr\left(K_i = 0,\ A_i = j, C_i = 0\right)\right]^{d_{ij}}
\end{aligned} \tag{9}
$$

Results

Data and Variable Definitions

In the paper, the methodology mentioned above has been applied to explain the purchasing intention of corn flakes. As the estimation of the trivariate model given by (1), (5) and (6), maximizing expression (9) is rather complex, we have estimated first each equation individually to have an idea of what should be the most relevant explanatory variables that should be included in each equation. Among the socio-economic variables, only the education level was found to be significant. Also, we found significant behaviour differences in respondents living in the South of Spain. In general terms, food habits (Table 1) were relevant to explain some of the dependent variables.

The complete list of variables included in the model is shown in Table 4. As we are dealing with corn flakes, we have included in the purchasing intention equation one dichotomous variable, which took the unit value if the respondent had bought corn flakes in the last three months and zero, otherwise. As consumers' price sensitiveness was null, taking into account the results mentioned in Section 2, the third equation has not been possible to be defined as a traditional willingness-to-pay equation. Alternatively, we have only measured the willingness-to-buy.

Finally, the questionnaire also includes some questions trying to detect what were the main attributes consumers took into account when purchasing foods. Respondents had to rate on a 1 to 5 scale the following attributes: price, convenience, safety, taste, nutritious and shelf life. We considered such responses could have some influence, at least, in the first two equations. Instead of including the six attributes we first carried out a factor analysis reducing the six variables to three factors, which explained 78% of total variance. The first factor "convenience" (F1, in table 4) was positively correlated with the convenience, taste and nutritious attributes. The second factor "safety" (F2 in Table 4) was positively correlated with the shelf life and safety attributes. Finally, the third factor "price" (F3 in Table 4) was positively correlated with the attribute of the same name.

Table 4. Definitions of Variables and Sample Statistics

Variable	*Definition*
Knowledge (K_i)	Information about GM foods before this survey (1= consumers were very well or somewhat informed; 0 = other case) (see Table 2)
Attitudes towards GM foods (A_i)	Willingness to consume foods produced with GM ingredients (1 = respondents were extremely or somewhat unwilling; 2 = respndents were indifferent or do not know; 3 = respondents were extremely or somewhat willing) (see Table 3, 2nd row)
Non-GM corn flakes purchasing intention (C_i)	Consumer does not show any intention of buying GM corn flakes (1 = respondents prefer non GM corn flakes; 0 = respondents prefer GM corn flakes or were indifferent)
Consumers awareness for convenience ($F1_i$)	Continous variable from factor analysis on main food atributes respondents take into account when buying food
Consumers awareness for safety ($F2_i$)	Continous variable from factor analysis on main food atributes respondents take into account when buying food
Consumers awareness for price ($F3_i$)	Continous variable from factor analysis on main food atributes respondents take into account when buying food
Frequency of purchasing organic foods (FOF_i)	How often you or members of your household buy organic foods (1= often or always; 0 = other case)
Frequency of purchasing fast foods or ready-made meals (FFF_i)	How often you or members of your household buy fast foods or ready-made meals? (1= often or always; 0 = other case)
Frequency of recycling paper, cans, or bottles? (FR_i)	How often you or members of your household recycle paper, cans, or bottles? (1= often or always; 0 = other case)
Dummy variables (1= yes; 0 = no)	
Low level of education (LE_i)	Respondent only has primary school
Medium level of education (ME_i)	Respondent only has secondary school
Use of labelling information (LI_i)	Respondent uses to look at the panel of nutritional information on the food package
Living in the south $(SOUTH_i)$	Respondent lives in the South
Recent purchase (FP_i)	Respondent purchased corn flakes within the last 3 months

Estimation results

In Table 5 estimated parameters for the three-equation model are shown. In general terms, signs of parameters are quite consistent with expectations. Socio-economic variables were not relevant, as mentioned above, except for the education level and the respondent's region of residence.

Table 5. Maximum-likelihood Joint Estimation of the Three-equation Model [a]

Variable	Knowledge (K_i)	Attitudes towards GM foods (A_i)	Non-GM corn flakes purchasing intention (C_i)
Constant	-1.05* (-2.28)	-0.04 (-0.82)	1.22* (5.13)
Knowledge (K_i)		-0.07** (-1.65)	
Attitudes towards GM foods (A_i)			-0.94* (-3.00)
Consumers' concern about convenience ($F1_i$)	-0.01 (-0.07)		
Consumers' concern about security ($F2_i$)	-0.10 (-1.04)	-0.17* (-2.02)	
Consumers awareness about price ($F3_i$)	-0.19** (-1.94)		
Frequency of purchasing organic foods (FOF_i)	0.22* (2.03)		
Frequency of purchasing fast foods or ready-made meals (FFF_i)		0.24* (1.46)	
Frequency of recycling paper, cans, or bottles? (FR_i)		-0.10** (-1.66)	
Low level of education (LE_i)	-0.66** (-1.67)		
Medium level of education (ME_i)	0.31 (0.79)		
Use of labelling information (LI_i)	0.48* (1.99)		
Living in the south $(SOUTH_i)$		0.81* (4.03)	-0.80* (-2.05)
Recent purchase (FP_i)			-0.47** (-1.86)
μ_2		1.04* (9.14)	
Log-likelihood	-1.94		

[a] One asterisk (*) denotes significance at the 5% level; two asterisks (**) denote significance at the 10% level.

High-educated consumers have a better knowledge, or at least, have collected more information, about GM technology. Also, people who normally are used to read food labels have shown more interest in knowing something about GM food products. Finally, in relation with the food attributes consumers take into account when purchasing

food, it seems that respondents more worried about food prices have a lower knowledge on GM foods. Finally, convenience and safety attributes have no influence on the information level respondents have on GM technology.

Consumers' knowledge on GM organisms is negatively related to positive attitudes towards GM food. This is not a very surprising result as respondents have gathered information on GM technology mainly through mass-media in which more attention has been paid, up to now, on negative implications of such technology. Similarly, respondents worried about safety issues when buying food or characterised by an active recycling behaviour show more negative attitudes towards GM products. On the contrary, consumers showing a higher frequency of buying fast food or ready-to-eat meals have more positive attitudes towards GM foods. Finally, at least for Spain, people living in the South seem to have more positive attitudes to such products.

The last equation shows main factors explaining the intention of Spanish consumers to buy GM corn flakes. As the dependent variable took the unit value for the non-GM cereal, a negative sign in the corresponding parameter will indicate some potential for future GM consumption. A positive attitude towards GM foods implies an intention to buy GM corn flakes. The same happens in the case of corn flakes regular consumers (more experienced consumers seem not to pay attention to characteristics of the raw commodity). Finally, Spanish respondents living in the South seem to exhibit a better predisposition to buy GM corn flakes.

Concluding remarks

The aim of this paper has been twofold. On one hand, attitudes and purchasing intentions of Spanish consumers towards GM foods and, particularly, towards GM corn flakes, as a case study, are analysed. On the methodological side, the paper has aimed to provide an econometrical framework, which was able to jointly model the hierarchy of effects in high involvement purchasing situations. It has been assumed that the degree of knowledge about GM technology affects attitudes towards GM food, which finally determine future purchasing intentions.

Using a similar questionnaire as previous studies in Norway and US, the paper shows a lower knowledge level about GM technology in Spain in comparison with the other two mentioned countries. Also, results from our survey clearly indicate a more negative attitude among Spanish consumers towards GM foods and, consequently, a lower intention to buy such GM foods.

The estimated model confirms some results found recently in the literature suggesting that purchasing food has become a high involvement decision and this is more evident when there can exist some consequences on human health or on the environment. Our results indicate a kind of a causal chain between knowledge, attitudes and purchasing intention. Higher educated consumers, more concerned about labelling information and less about price, and regular buyers of organic foods show a higher (not necessarily better) knowledge on GM technology and its consequences. However, those consumers with a lower level of knowledge, together with those who are less concerned about food safety issues, are not used to recycle but to purchase fast food exhibit a more positive attitude towards GMs in Spain, which finally determine future purchasing intention.

Results obtained in this paper have to be considered only as the outcome of a case study. Further extensions to other products and other countries are needed to get a final

conclusion about consumers' behaviour in relation to GM foods. On the methodological side, our aim has been only to provide an alternative strategy to other modelling approaches as structural equations modelling, commonly used in marketing research.

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